HIDING IN PLAIN SIGHT: AN ANALYSIS OF THE ‘FEMALE CAMOUFLAGE EFFECT’ IN YOUNG AUTISTIC FEMALES

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ABSTRACT

Jessica Elizabeth Goldblum: Hiding in Plain Sight: An Analysis of the 'Female Camouflage Effect' in Young Autistic Females'
(Under the direction of Cathi Propper and Clare Harrop)

Evidence suggests that ASD females "camouflage", or mask, social difficulties in order to successfully navigate social situations. However, as ASD diagnostic tools account for social difficulties, camouflaging may prevent females from receiving an ASD diagnosis. Little research has examined early evidence of camouflaging, particularly in young children. In a study of 78 ASD boys and girls matched linguistically, diagnostically, and by chronological and developmental age, we completed a microanalysis of social communication. We hypothesized that while boys and girls demonstrated social difficulties on matched scores, girls would exhibit more joint attention, consistent with camouflaging. MANOVA analyses demonstrated that compared to boys, girls utilized more joint attention, with results driven largely by chronological and developmental age. This research demonstrates that young ASD girls appear to engage in emerging camouflaging behaviors to mask social difficulties, which has important implications for diagnostic tools that may not capture girls during the diagnostic process.

To my wonderful family, near and far. You have made this all possible.
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ASD	Autism Spectrum Disorders
ADOS	Autism Diagnostic Observation Schedule
BR	Behavioral Request
ESCS	Early Social Communication Scales
JA	Joint Attention
IJA	Initiating Joint Attention
IBR	Initiating a Behavioral Request
MSEL	Mullen Scales of Early Learning
RJA	Responding to Joint Attention
RBR	Responding to a Behavioral Request

Introduction

Autism spectrum disorder (ASD) is characterized by two core features: restricted and repetitive patterns of behavior and difficulties with social communication and interaction (Volkmar et al., 2004). ASD is a highly heterogenous neurodevelopmental disorder. Although functionally characterized by the core features above, more often than not a diagnosis of ASD includes additional indicators and co-occurring conditions, from internalizing symptomatology such as anxiety to medically co-occurring problems such as gastrointestinal dysfunction (McCormick et al., 2020; Veenstra-Vanderweele & Blakely, 2012). The most current edition of the Diagnostic and Statistical Manual of Mental Disorders (American Psychiatric Association, 2013) uses ASD as an umbrella term that includes autistic disorder, Asperger's disorder, and pervasive developmental disorder – not otherwise specified. However, ASD is now thought to encapsulate not just one but *many* spectrums (Coleman & Gillberg, 2011; Gillberg & Fernell, 2014). While significant advances in diagnostic instruments and behavioral identification of ASD have been made in the last two decades (Volkmar et al., 2004), ASD diagnoses can be challenging as no one person on the spectrum is alike.

Biological sex is one such factor that contributes to ASD heterogeneity. ASD is a "predominantly male" disability believed to affect one female for every three-to-four males (Fombonne, 2009; Loomes et al., 2017). However, ASD females remain largely understudied, are thought to be underdiagnosed, and are diagnosed between at least a year, if not two or more years later than ASD males (Bargiela et al., 2016; Duvekot et al., 2017; Harrop et al., 2020; McCormick et al., 2020; Salomone et al., 2015). Researchers have long sought to explain the

ASD male predominance, but with much difficulty. Some research has shown that the male ASD predominance is fraught with bias (Head et al., 2014; Sedgewick et al., 2016), attributable to the fact that ASD females are simply not diagnosed at a rate comparable to ASD males. The authors reason that the lack of female diagnosis could be due to factors including phenotypic sex differences, sensitivity of diagnostic materials, and even the "male" history of ASD. However, in a systematic review of sex differences in ASD by Werling & Geschwind (2013), even after accounting for variance in ASD trait presentation and biological and genetic correlates of the disorder, the authors concluded that while further research is needed to mechanize this diagnostic disparity, the ASD male predominance still stands.

Ultimately, ASD females are underserved in their access to successful and timely diagnostic services. Further research on what has been coined a female "ascertainment bias" (Bargiela et al., 2016) in ASD is paramount, as late or lack of diagnosis prevents ASD females from receiving intervention services that are vital for overall functioning and mental health. Indeed, Bargiela, Steward, and Mandy (2016) examined a sample of 14 late-diagnosed ASD women and found that the majority of the sample not only had experienced elevated incidence of clinically severe anxiety but also alarming rates of sexual abuse.

The Female Autism Phenotype

Although all ASD individuals exhibit social difficulties and restricted/repetitive patterns of behavior to some extent, research has shown that male and female ASD characteristics can appear vastly different and ASD diagnostic criteria may be more accurate if it were likewise to differ by sex (Hull et al., 2017). Research has shown that ASD females tend to have fewer restricted and repetitive behaviors (RRBs) (Frazier et al., 2014; Mcfayden et al., 2020) and more social behaviors than ASD males (Dean et al., 2017; Frazier et al., 2014; Lai et al., 2011;

Mcfayden et al., 2020; Sedgewick et al., 2016). RRBs that typically *are* exhibited by ASD females tend to be demarcated as archetypal in nature to typically developing (TD) females (animals and dolls), making detection of ASD female RRBs more difficult. Interestingly, Duvekot et al. (2017) found a significant interaction between biological sex and RRBs such that, even when females exhibit higher levels of RRBs, high RRB scores in females were less predictive of an ASD diagnosis compared to high RRB scores in males.

While ASD females and males may appear to exhibit similar overall social communication difficulties on diagnostic assessments, ASD females may present better on specific modes of social communication (i.e., non-verbal language) compared to ASD males when fine-grained analyses are used. For example, (Rynkiewicz et al., 2016) coded for vivacity of gesture use in 5-10 year-old ASD children when completing the Autism Diagnostic Observation Schedule (ADOS-II; Gotham et al., 2006) and found that ASD girls displayed more vivid presentations of gestures than did ASD boys. Better non-verbal communication in ASD girls may mirror slight sex differences in the emergence and use of non-verbal communication seen in TD. For example, Butterworth & Morissette (1996) observed sex differences in the onset of pointing in TD infants across five time points and found that pointing emerged in girls slightly before boys. Chipman & Hampson (2007) found evidence of biological sex differences in gesture use among preschoolers as well as a specific female advantage with gesture imitation compared to males. Therein, ASD girls may develop and use specific modes of social communication before ASD boys similar to the female advantages in TD. However, while gold-standard ASD diagnostic assessments measure non-verbal communication and gestures, fine-grained analyses of specific social communication modes do not usually take place which may not allow us to fully capture ASD girls within the diagnostic process.

In addition to social communication, research shows that ASD girls may have further social advantages compared to ASD boys as evidenced by friendship behaviors, social motivation, and social awareness. Head et al. 2014 found that ASD girls demonstrate more complex social skills on friendship quotient scales than do ASD boys, exhibiting levels similar to those of TD males. Sedgewick et al. 2016 demonstrated that young ASD girls tend to exhibit social motivation and friendship behaviors similar to young TD girls compared to young ASD boys who report less social motivation. Researchers have also speculated that ASD females may have a greater awareness of their social impairments than do ASD males (Rynkiewicz & Łucka, 2018; Schuck et al., 2019). Sex differences in ASD have led several experts in autism research to propose a separate female autism phenotype altogether, necessitating diagnostic criteria particularly sensitive to capturing females on the spectrum (Bargiela et al., 2016; Hull et al., 2020). As ASD females exhibit less overall ASD traits, slight advantages in social communication and interaction, and greater ability to recognize ASD impairments compared to ASD males, it follows that ASD females may be underserved in diagnosis because they are able to successfully mask, or "camouflage," behavioral and symptomatic indicators of their autism (Rynkiewicz & Łucka, 2018).

The Female Camouflage Effect

Research on camouflaging, the use of conscious or unconscious strategies to compensate for and mask social difficulties that stem from ASD, has become a burgeoning field of study particularly with ASD females (Head et al., 2014; Hull et al., 2020; Lai et al., 2015; Rynkiewicz & Łucka, 2018; Wing, 1981). In the aforementioned qualitative study of late-diagnosed women with autism by Bargiela et al. (2016), participants described the camouflaging phenomena as their attempts to "pretend to be normal". Participants camouflaged their social difficulties in public by mimicking the social behaviors of others and using learned phrases, facial expressions, and forced eye contact. Although a new field, research has already established that ASD females camouflage significantly more often than their ASD male counterparts (Lai et al., 2015; Schuck et al., 2019). Therein, this phenomenon has been called the "female camouflage effect."

Although this compensatory social strategy may yield short term benefits, camouflaging has shown to be exhausting and is associated with elevated distress and mental health concerns (Bargiela et al., 2016; Hull et al., 2017, 2019; Rynkiewicz et al., 2016). In a seminal qualitative study of social camouflaging in 92 ASD adults, Hull et al. (2017) examined a particular consequence of camouflaging experienced by both males and females described as a profound "loss of personal identity". Participants reported that recurrently masking their social behaviors continually caused them to challenge their self-perceptions and to identify their behavior as "fake" or inauthentic. Camouflaging may be a particular problem for ASD females and specifically adolescent ASD females, who are already at a higher risk of developing mental illness and/or mood disorders than adolescent ASD males (Jamison et al., 2017; Solomon et al., 2012). For ASD females, camouflaging is just another added burden to bear.

Camouflaging in Early Childhood

Several studies have begun to assess camouflaging in ASD school children. Dean, Harwood, & Kasari (2017) examined a sample of 48 1st through 5th grade ASD children (mean age = 7.73) by coding their social behaviors during activities at recess categorized into games, joint engagement activities, and solitary activities. The authors found that social behaviors in ASD girls supported the female camouflage effect. More specifically, boys engaged in more solitary play activities which allowed for easier detection of social challenges; although girls also faced substantial social difficulties, they were harder to detect. By sticking close to peers and moving in and out of social activities, the ASD girls managed to compensate for their social challenges. Evidence of the female camouflage effect in 5-10 year-old ASD children was shown in the aforementioned study of gesture vivacity during the ADOS-II by Rynkiewicz et al. (2016). High scores of autism traits on the Autism Quotient and parent-reported scores of social impairment on the Social Communication Questionnaire across two timepoints did not significantly differ by sex, indicating that both ASD boys and girls had enduring social difficulties; however, ASD girls displayed more vivid presentations of gestures than boys during the ADOS-II. As the ADOS-II measures impairments in social communication, including gesture use, this finding demonstrates that gesture use and other camouflaging behaviors can buffer ASD girls from receiving a poor ADOS social communication score, possibly deterring a proper ASD diagnosis.

While there is evidence that the female camouflage effect emerges in childhood, little research has examined camouflaging in ASD children younger than the age of five. Children on the autism spectrum can be reliably diagnosed at 18 months of age (Zwaigenbaum et al., 2020) and an early diagnosis allows for intervention at a younger age, linked to better outcomes and overall quality of life (Lord, 1995). Studying camouflaging at its earliest is a critical step in narrowing ASD ascertainment bias in females. Therein, a comprehensive understanding of the earliest social communication behaviors is necessary in order to discern which behaviors young ASD children could possibly use to camouflage social impairment. Grounded by the neural network models of attention and the cognitive-developmental framework of social communication, we herein present an overview of the emerging behaviors that define social communication in the earliest years of typical and neurodiverse development.

Early Social Communication Behaviors Defined

Early social communication can be dichotomized into two categories: the use of eye contact and verbal and non-verbal language to signal or respond to a behavioral request (BR) or joint attention (JA) (Mundy et al., 2003). Behavioral requests are defined as linguistic behaviors that indicate a want or need. Children often initiate BR by reaching or pointing in order to acquire a favorite toy or giving an object to another in order to seek help using it. Joint attention is defined as the initiation of, or response to, social signals of engagement ("shareable moments") between two social partners (Mundy & Van Hecke, 2019). For example, a child might engage in JA by using eye contact and pointing to share excitement about a new toy with her mother. While the use of BR necessitates communicating with others to request, engaging in JA is an inherently social process of establishing shared intentionality, unique to human social cognition (Tomasello & Carpenter, 2005). Therein, as the use of JA defines effective social communication in the first years of life, JA is a primary focus of this study.

JA can be partitioned into two subtypes: initiating joint attention (IJA) and responding to joint attention (RJA). Mundy & Jarrold (2010) posit that IJA and RJA follow two divergent bio-behavioral paths of development, although they seem to integrate and work in tandem early in life, ultimately forming a distributed and integrated neural network. RJA is conceptualized as an automatic process beginning in the first 3 months of life by which the infant posterior cortical attention system regulates attention orienting to relevant stimuli within the infant's environment. In contrast, IJA is associated with frontal-cortical activity, thought to be regulated by the anterior cortical attention network. Primarily unique to humans, the later-developing anterior cortical network supports spontaneous, volitional, and goal-directed behaviors. During episodes of coordinated attention, JA is vital for and is thought to enhance information processing and encoding in the first year of life. Near the second year of life, engagement in JA is thought to underlie our ability to unify social coordination and attention with internal representations, or symbolic thought (Mundy & Jarrold, 2010). Notably, as difficulties with social communication are a core feature of ASD, ASD children tend to exhibit a lack of, poor, or delayed IJA and RJA (Kasari et al., 2006; Volkmar et al., 2004; Wetherby et al., 2007).

The cognitive-developmental framework of social communication can be categorized into five developmental stages, similar to the six sensorimotor stages proposed by Piaget (Mundy et al., 2003; Seibert et al., 1987). After simple reflexive behaviors in the first months of life, children enter the second stage in which they engage in simple voluntary actions such as looking, reaching, and vocalizing (Seibert et al., 1987). This stage includes the earliest JA and BR behaviors: reaching gestures emerge in the first 3-4 months of TD (Berthier & Keen, 2006) and the capacity for gaze following (RJA) appears between 3- to 6-months of age in TD children (Morales et al., 1998, 2000; Mundy & Van Hecke, 2019).

Importantly, ASD children tend to exhibit impairments in these early stages. ASD children show marked difficulties with RJA and in the production of gestures such as reaching, and these specific difficulties are often the earliest and most powerful diagnostic indicators of ASD (Kasari et al., 2006; Mundy & Crowson, 1997). Children's gesture "inventories" at 2 years of age were one of the two strongest predictors of ASD traits at age 3 (the other predictor being BR) and when controlling for age and understanding, also predicted children's nonverbal developmental quotients at age 3 (Wetherby et al., 2007). Vaughan Van Hecke et al. (2007) found that RJA together with IJA abilities at 12 months were related to 30-month social and behavioral competence, even after accounting for child temperament ratings at 15 months, 24-month language and cognition, and demographic variables.

The third stage of social communication development is characterized by the development of behavioral and visual preference which arise from the infant's newfound ability to engage in differentiated action: distinguishing an object or person from another and acting accordingly (Seibert et al., 1987). Subsequently, the fourth stage is defined by nonsymbolic sensorimotor development and the ability to attend to two items simultaneously. The child is able to engage in simple, conventional social behaviors – such as waving "goodbye," – and can begin to coordinate his social partner's attention with an object (IJA) (Seibert et al., 1987). Within these stages, pointing, giving, and showing gestures also emerge, allowing for more sophisticated BR or JA (Brady et al., 2004). 9- and 9.5-month-olds begin to partake in giving and showing gestures (Watson et al., 2013) and at about 12 months pointing gestures emerge (Butterworth & Morissette, 1996; Watson et al., 2013). At this age, notable differences in gesture use between ASD and TD infants can be observed. Watson et al. (2013) examined JA and BR behaviors in the 9-12-month-old age group from parent-recorded home videos and found that ASD infants were less likely than TD infants and infants with other developmental disabilities to use JA gestures and less likely than TD infants to use BR gestures.

The fifth and sixth stages of the cognitive-developmental framework combine symbolic development with coordinated, conventional communication skills (Seibert et al., 1987). TD children tend to achieve this stage by 30 months of age, characterized by higher-skilled and combinatory JA and BR behaviors (Mundy, 2003). Children begin to pair multiple JA or BR behaviors together, along with appropriate and accompanying language, affectivity, and emotion. For example, a young child might point, say "look," and engage in eye contact with their social partner to communicate. Effective social communication, along with symbolic play (Ungerer & Sigman, 1981) is critical for representational and symbolic thought. However, many ASD children may never achieve these stages while others will have difficulty developing *comprehensive* social communication use. For example, an ASD child might point to show their social partner an object but may not use eye contact, verbal language, or appropriate affect. While the point alone may be sufficient for obtaining the social partner's attention, lack of accompanying social descriptors may present communication challenges for both parties.

In summary, ASD children experience inherent difficulties with social communication, particularly JA, from an early age. However, ASD girls may exhibit slight social and linguistic advantages (friendship behaviors, non-verbal language) compared to ASD boys (Butterworth & Morissette, 1996; Chipman & Hampson, 2007) and may be more likely to learn from and mimic the social communication use of others (Bargiela et al., 2016; Hull et al., 2017, 2020; Schuck et al., 2019). ASD females tend to be better at recognizing their communication difficulties and may have higher levels of motivation to correct for this disadvantage (Rynkiewicz & Łucka, 2018; Schuck et al., 2019). Moreover, research has shown that even school-aged ASD girls demonstrate camouflaging to overcome their social difficulties around peers and during ASD diagnostic tests (Dean et al., 2017; Rynkiewicz et al., 2016) However, when does camouflaging emerge? Might even the youngest ASD girls demonstrate evidence of an emerging female camouflage effect? The current study examines the emergence of social camouflaging behaviors in early childhood ASD.

The Current Study

The current study is a microanalysis of JA and BR behaviors in very young ASD children previously examined in research by (Harrop et al., 2015). The authors examined the influence of biological sex on social communication behaviors in 80 developmentally, linguistically, and diagnostically matched ASD girls and boys and found that while girls initiated and responded more to JA and BR, this difference was not significant. While the authors concluded that social communication scores in this sample appeared similar by biological sex, individual categories of JA and BR behaviors were not examined. Importantly, evidence suggests that when diving deeper into social communication assessments (i.e., micro-coding), minute but discrete differences may be seen in linguistic and social behaviors used by ASD girls (Hull et al., 2017; Rynkiewicz et al., 2016; Schuck et al., 2019). Therein, this study leverages a large, matched sample to examine the impact of biological sex on JA and BR behaviors at the micro level. Although both sexes exhibit persistent social difficulties as evidenced by matched developmental, linguistic, and diagnostic scores, we hypothesize that a microanalysis will reveal more frequent and higher-skilled social communication use (more JA) in young ASD girls, which may be an early marker for camouflage in ASD females. This research serves to engage in a greater understanding of very young ASD females and the adaptive skills they may use to mitigate some of their challenges, potentially aiding in earlier detection and treatment and better quality of life.

Method

Participants

A group of young ASD females (N=40) and males (N=40), aged 26 to 58 months, were sampled for this study. Boys were matched with girls by chronological and mental age using initial study allocation and scores on the ADOS (ADOS-II; Gotham et al., 2006) and Mullen Early Scales of Learning (MSEL; Mullen, 1995). One female participant was assessed with the ADOS with an interpreter present. A separate female participant was missing scores for MSEL age equivalent and chronological age, so that case and its matched pair were removed from the sample. One female participant was missing an ADOS score (due to no available Spanishspeaking interpreter for the assessment) but was included in study analyses as they had all other data available. Our final sample size was 78 ASD children with equal groups of girls (N=39) and boys (N=39) (Table 1). The sample of 39 girls represented all female participants with social-communication data across the four intervention studies.

Participant Recruitment and Respective Intervention Studies

Study one was a home-based randomized control trial (RCT) targeting families with low resources. 36- to 48-month-old children were randomly assigned to a parent-mediated intervention targeting symbolic play and JA or a group treatment approach. Five girls from the UCLA study one site were included in our sample. Sixteen girls were recruited from the UCLA site study two. Study two was a lab-based RCT for ASD children aged 22 to 36 months in which participants were randomized to a parent-mediated intervention targeting symbolic play and JA or a parent education intervention. Study three was a school and home-based RCT for minimally-verbal children aged 33 to 54 months in which children were assigned to a symbolic play and JA intervention or Discrete Trial Training. Six girls from the study three UCLA site were recruited and included in our sample. Lastly, thirteen girls were recruited from study four. Study four was a pre-school based teacher-mediated intervention for children aged 36-59 months, who were randomly assigned to immediate or delayed treatment. Children recruited from each study completed measures at time of study entry (Table 1).

Matching Procedures

Boys were individually matched to girls based on respective intervention study and the following criteria: identical ADOS module at study entry and scores within a one-point match on the ADOS algorithm total score. If multiple matches were available, girls were matched to boys with the closest chronological age and/or developmental quotient on the MSEL. The female participant with a missing ADOS score was matched via MSEL developmental quotient and chronological age. For more details on matching procedures, see Harrop et al. (2015).

Measures

The Autism Diagnostic Observation Schedule. Eligible children in each study were administered the Autism Diagnostic Observation Schedule (ADOS-II; Gotham et al., 2006) to confirm an ASD diagnosis and assess general social functioning. After diagnostic confirmation, in order to obtain language and developmental quotient scores, children were administered the MSEL. Children subsequently completed a structured play assessment and the Early Social Communication Scales.

The Early Social Communication Scales. The Early Social Communication Scales (ESCS) (Mundy et al., 2003), an assessment for children 14-30 months of age, was utilized to obtain measures of children's verbal and non-verbal social communication use. The ESCS uses a variety of stimulating toys (wind-up toys, balloons, a hat, comb, and glasses, a book, ball, and car), prompts, and situations to elicit children's spontaneous and requested initiations of JA and BR. The interaction lasts about 20 minutes and is video recorded for later behavioral coding. The child sits at a table facing the examiner. To the side of the examiner, and out of reach of the child, the child can see a standardized set of toys. One at a time, the examiner activates a toy, still out of reach of the child, prompting her to use social communication to obtain the toy.

The assessment includes a variety of prompts to determine how children respond to JA and BR of the examiner. Four colorful posters are placed around the room to the left, right, and back-left and back-right of the child. With these posters, the examiner intermittently looks at the wall posters, says the child's name, and points. Additionally, the examiner shows a book to the child and intermittently points at items on pages to the child's left and right. These tasks are coded for RJA. The examiner also intermittently prompts the child with the phrase, "give it to me," a measure of responding to a BR, when the child has a toy.

All social communication behaviors are coded by type and frequency, and types include initiates joint attention (IJA), responds to joint attention (RJA), initiates behavioral request (IBR), and responds to behavioral request (RBR). IJA refers to a child's spontaneous usage of JA skills– including pointing, eye contact, showing, etc. – to share something with the examiner. For IJA, children's eye contact was coded as either a coordinated joint look (a triadic gaze between an object and examiner) or an alternate gaze (a look from the examiner to an object, or vice-versa). Giving, pointing, and showing IJA bids were also coded. RJA accounts for children's responses to the examiner's JA throughout the assessment. RJA behaviors were codified as the percent of the child's responses to JA over the total number of RJA trials within two tasks: Line of Regard and Book Points. The line of regard task involves two trials in which the examiner points to four pictures around the room and children's response (or lack thereof) are coded each point (for a total of 8 possible responses). Within the book pointing task, the examiner points to various items in a picture book, and similarly, children's responses are coded and divided by the total number of trials.

IBR quantifies how often the child elicits aid from the assessor, including asking for help in opening, starting, or obtaining toys/objects. IBR behaviors that were coded were: giving, pointing, and reaching. Lastly, RBR measures how the child responds to the examiner's behavioral requests for a toy. The examiner says, "give it to me," on the second or third presentation of a mechanical toy trial once the child has played with the toy for around 10 seconds. If the child gives the toy, the RBR trial is complete. If the child does not respond, the examiner requests the toy two more times, and if still no response, continues to request with an open palm gesture. Children's number of responses are totaled and divided by the number of "give it to me" requests from the examiner, for a total percentage score. ESCS scores were originally coded for research by Harrop et al. (2015). Intraclass Correlation Coefficients (ICCs) were high and did not significantly differ by children's respective study. Total ICCs for ESCS scores were as follows: total frequency of IJA ($\boldsymbol{\alpha}$ = 0.93), RJA ($\boldsymbol{\alpha}$ = 0.95), IBR ($\boldsymbol{\alpha}$ = 0.96) and RBR ($\boldsymbol{\alpha}$ = 0.88).

Analytical Strategy

SPSS IBM Statistics software (IBM Corp) was used to conduct study analyses. Independent samples t-tests were used to examine possible sex differences in age in months at assessment entry, MSEL age equivalents and developmental quotients at entry, and receptive and expressive language age equivalents. Children did not significantly differ in respect to age in months at entry [$t(38)=0.62$, $p=.54$], MSEL age equivalents at entry [$t(38) = 0.10$, $p=0.91$], MSEL developmental quotients at entry [$t(38)=-0.12$, $p=.90$], or expressive language equivalents [$t(38)=-0.01$, $p=0.99$] and receptive language equivalent [$t(38)=-0.24$, $p=0.81$]. Chronological age and MSEL age equivalents at entry were positively correlated [$r=.597$, $N=78$, $p=.000$].

MANOVAs tested for possible biological sex differences in ESCS bids and responses in order to examine evidence of the emerging camouflaging behaviors in this young sample. Interaction effects of participants' chronological age and MSEL age equivalents on sex were also examined to determine whether children's cognitive performance or linear age moderated relationships between sex and frequency of JA or BR bids or responses.

Results

Initiating Joint Attention (IJA)

To begin, we examined possible sex differences in ESCS IJA behaviors as evidenced by eye contact (alternate gaze, coordinated joint looks) and gestures (gives, points, and shows) initiated by the child to engage socially with the examiner.

IJA Alternate Gazes. We examined whether ASD boys and girls showed marked differences in incidence of alternate gazes (two-point looks between an examiner and a toy or vice versa). We found no significant sex difference in boys' and girls' mean levels of IJA alternate gazes [$F=.026$, $p=.872$]. To examine whether child chronological ages or MSEL age equivalents moderated effects of biological sex on frequencies of alternate gazes, interaction effects were tested. No significant interactions were found between chronological ages or MSEL age equivalents on alternate gazes and biological sex.

IJA Coordinated Joint Looks. Next, we examined possible sex differences in frequency of children's coordinated joint looks (or triadic gazes), considered to be a higher-skilled level of IJA eye contact. There was no significant main effect of biological sex on coordinated joint looks [$F=.00$, $p=.93$]. Interaction effects were subsequently examined. Although no interaction effects were found for chronological ages, children's MSEL age equivalents significantly moderated the relationship between biological sex and coordinated joint looks [$F = 7.79$, $p = .001$, $\eta^2 = .18$] (Figure 1). In other words, more cognitively advanced females use more coordinated joint looks than cognitively advanced males. Conversely, less cognitively advanced females used lower amounts of coordinated joint looks to initiate JA.

IJA Gives. We analyzed possible sex differences in IJA giving bids. There was no significant main effect of biological sex on IJA giving bids [$F = .208$, $p = .654$]. Similar to IJA coordinated joint looks, although there was no biological sex by chronological age interaction, MSEL age equivalents significantly moderated the relationship between biological sex and IJA giving bids [$F = 5.56$, $p = .006$, $\eta^2 = .13$]. More cognitively advanced females exhibited greater incidence of giving behaviors compared to cognitively advanced males. However, large floor effects were exhibited in giving behaviors, so we are cautious to make light of this finding.

IJA Points. To examine possible sex differences in IJA points, we analyzed group mean differences in ASD boys' and girls' pointing frequency. No significant main effect of biological sex on points was found [$F = 2.14$, $p = .15$], indicating that girls' and boys' mean levels of IJA points did not significantly differ due to biological sex. We subsequently examined possible interaction effects of chronological ages and MSEL age equivalents. No significant interaction effects were present for children's chronological ages. However, we found a significant interaction effect of MSEL age equivalents on the relationship between biological sex and IJA points [$F = 3.85$, $p = .026$, $\eta^2 = .09$] (Figure 2). Children's age equivalents moderated the effect of biological sex on IJA points such that females who were more cognitively advanced utilized more IJA points than cognitively advanced males. Conversely, less cognitively advanced females used fewer IJA points compared to their less cognitively advanced male counterparts.

IJA Shows. Finally, we examined whether ASD boys and girls showed marked differences in incidence of showing bids. The effect of biological sex on showing bids approached significance [$F=3.25$, $p = .076$] although power was low. To examine whether children's chronological ages or MSEL age equivalents moderated effects of biological sex on showing bids, interaction effects were tested. No significant interaction effect of MSEL age equivalents on biological sex and showing bids was found. A moderation effect of chronological age on the relationship between biological sex and IJA shows approached significance [$F = 2.59$, p = .082]. However, similar to IJA gives, there were large floor effects in children's IJA shows so we are cautious to draw conclusions from this finding.

Responding to Joint Attention (RJA)

Subsequently, we analyzed RJA behaviors as evidenced by children's percentage of examiner pointing bids correctly followed (responded to) with eye contact.

RJA Book Points. Possible sex differences in ASD boys' and girls' percent correct responses to book points were analyzed. No significant main effect of biological sex on book point percentages was found [F=1.5, p=.23]. However significant interactions were found. Chronological age significantly moderated biological sex and its effect on RJA book point percentages [$F = 4.26$, $p = .018$, ŋ2 = .106] (Figure 3). MSEL age equivalents significantly moderated the effect of biological sex on RJA book point percentages [$F = 3.10$ $p = .051$, ŋ2 = .08] (Figure 4). Therefore, more cognitively advanced females and older females were more likely to respond to the examiner's book points.

RJA Line of Regard. We next analyzed possible sex differences in percentage of correct responses to line of regard trials. There was no significant main effect of biological sex on IJA Line of Regard [$F = .145$, $p = .70$). There was no biological sex by chronological age interaction. However, MSEL age equivalents significantly moderated the relationship between biological sex and RJA Line of Regard [$F = 15.12$, $p = .000$, $ŋ^2 = .30$] such that females responded more to an examiner's line of regard points when they were more developmentally advanced (Figure 5).

Initiating Behavioral Requests (IBR)

Next, we examined possible sex differences in ESCS IBR behaviors as evidenced by gestures (gives, points, and reaches) initiated by the child to request something of the examiner.

IBR Gives. Biological sex differences in IBR gives were examined. No main effect of sex on IBR gives was found. There was no significant interaction effect of biological sex on IBR gives by chronological ages or by MSEL age equivalents.

IBR Points. Possible sex differences in pointing bids to initiate a behavioral request were examined. A significant main effect of biological sex on IBR pointing bids was found [$F=7.85$, $p = .007$, $\eta^2 = .09$). Our finding indicated that ASD males pointed to request, on average, significantly more than ASD females (mean of 4 points vs. mean of 3.02 points). We next examined interaction effects. While there was no significant interaction effect of biological sex on IBR points by MSEL age equivalents, chronological ages significantly moderated the relationship between biological sex and IBR pointing bids [$F = 5.53$, $p = .006$, $\eta^2 = .13$] (Figure 6). In other words, older males were more likely to use pointing bids to request compared to older females. Interestingly, wherein more cognitively advanced females used more IJA points (a social behavior), older males used more IBR points (a requesting behavior).

IBR Reaches. Next, we examined possible sex differences in IBR reaching bids. We found no main effect of biological sex on IBR reaches. No interaction effect was found for MSEL age equivalents on the relationship between biological sex and IBR reaches. However, a significant interaction was found such that chronological ages moderated the effect of biological sex on IBR reaches [$F = 5.20$ $p = .008$, $\eta 2 = .12$] (Figure 7). In other words, older males used more reaching behaviors to request compared to older females.

Responding to Behavioral Requests (RBR)

Finally, we analyzed RBR behaviors as evidenced by the percentage of examiner behavioral requests that the child responded to correctly.

RBR: Responding without Gestures. We examined biological sex differences in responding to behavioral requests, specifically, "give it to me" without an open-palm gesture. A significant main effect of biological sex on RBR without Gestures was found such that females responded more than boys [$F = 9.1$, $p = .004$. $\eta^2 = .11$]. Females had a mean correct response rate of 34.81% while males had an average of 22.61%. We next examined possible interactions and found that chronological ages significantly moderated the effect of biological sex on RBR without Gestures [$F = 3.10$, $p = .051$. $\eta^2 = .08$] (Figure 8). In addition, MSEL age equivalents significantly moderated the effect of biological sex on RBR without Gestures [$F = 7.72$, $p = .001$. $\eta^2 = .18$] (Figure 9). Thus, more cognitively advanced females and older females were more likely to respond to RBR without Gestures compared to boys.

RBR: Responding with Gestures. We examined biological sex and RBR requests with gestures (an open palm with the command, "give it to me"). A significant main effect of biological sex on RBR with Gestures was found such that females responded more compared to males [$F = 4.78$, $p = .03$, $\eta^2 = .06$]. Females had, on average, a 42.11% response rate, while males had an average response rate of 28.7%. No interaction effect was found for MSEL age equivalents on the relationship between biological sex and RBR with Gestures. An interaction approached significance such that chronological ages moderated the effect of biological sex on RBR with Gestures [$F = 2.82$, $p = .066$, $\eta^2 = .07$] (Figure 10).

Discussion

In a large, matched sample of young ASD girls and boys, a microanalysis of JA and BR behaviors yielded nuanced sex differences in early social communication profiles. Overall, young ASD boys were more likely to initiate with BR gestures (pointing and reaching) to achieve a want or need while young ASD girls were more likely to initiate and respond for social reasons. Girls engaged in more initiating and responding to JA, and interestingly, responding to BR with effects driven largely by MSEL age equivalents, and sometimes, chronological age. Therein, as girls were more likely to demonstrate JA behaviors compared to developmentally, linguistically, and diagnostically matched boys, our results confirm that even young ASD girls may engage in emerging camouflaging behaviors. In other words, although girls exhibited persistent social difficulties as evidenced by their matched ADOS scores, our microanalysis revealed that ASD girls engaged in more frequent and higher-skilled social communication use compared to ASD boys, perhaps demonstrating the emergence of social camouflaging.

The higher incidence of JA seen in young ASD females, compared to young ASD males, and the possibility of emerging camouflaging behaviors could, again, be due to a number of factors including a greater awareness of social difficulties as well as slight social and linguistic advantages that may mirror TD (Butterworth & Morissette, 1996; Chipman & Hampson, 2007). While our results cannot speak to social motivation, our results suggest that being female and being an older or more developmentally "advanced" female may play important roles in the emergence of possible camouflaging behaviors. We found that girls with higher MSEL age equivalents were more likely to initiate JA with eye contact (coordinated-joint looks) and gestures (pointing and giving). Additionally, girls with higher MSEL age equivalents responded at a greater rate to examiner line of regard and girls with higher MSEL age equivalents and girls who were older responded significantly more to examiner book points. Therefore, although both ASD boys and girls may still show difficulties with JA, older and more developmentally advanced ASD girls, and ASD girls in general, may still develop JA use before ASD boys.

Interestingly, ASD girls also responded to BR at significantly higher rates than boys. Our results yielded a significant main effect of sex on responding to BR such that girls, compared to boys, responded more to examiner "give it to me" prompts with and without a paired hand gestures. Additionally, we found moderation effects of chronological ages and MSEL age equivalents on responding to BR such that older girls responded more to "give it to me" prompts with the paired hand gesture, and both older and more developmentally advanced girls responded significantly more to "give it to me" prompts without the paired hand gesture. While we did not predict that girls would respond more to BR, we hypothesize that this may be due to a similar influence of social motivation, social awareness, and developmental and chronological age on compliance. In other words, girls may be more aware of their social difficulties in the face of examination, or may want to please the examiner more, therefore engaging in higher compliance to examiner prompts.

In addition, studies that examine early JA behaviors in young ASD children might be well served to measure IJA and RJA as two separate neurodevelopmental constructs all together. Indeed, Nyström, Thorup, Bölte, & Falck-Ytter (2019) state the importance of studying RJA and IJA as two separate and differential subcomponents of the JA dynamic, each with differing developmental trajectories, brain networks, and contributions to later linguistic and cognitive outcomes (Beuker et al., 2013; Gredebäck et al., 2010). In particular, Nyström et al. note that in neurological studies of adults, exhibition of IJA behaviors is associated with greater activation in the ventral striatum (VS) as well as other areas that serve to process reward while RJA is seen as a more automatic process. Given our findings that young ASD girls show more IJA and RJA behaviors compared to ASD boys and the fact that ASD girls tend to show greater levels of social motivation, this could be indicative of greater VS activation patterns in girls similar to those of TD peers (or perhaps ASD boys may have less VS activation during social situations).

Strengths

This study had a number of strengths. This study utilized the same data from a study of sex differences in ASD by Harrop et al. (2015) which found that ASD girls and boys tended to look more similar than different on global measures of play and social communication. However, our results indicate that when examining social communication at the micro level, this same sample of ASD girls and boys showed discrete differences. Females demonstrated higher-skilled social behaviors compared to boys, providing evidence of behaviors associated with camouflaging. Therein, this is the first known study to demonstrate the possible emergence of the female camouflage effect in ASD females younger than the age of five.

Our study specifically focused on the behaviors associated with camouflaging via a microanalysis of social communication behaviors in children aged 26 to 58 months. While prior research has shown that camouflaging behaviors may emerge in ASD females as young as five (Dean et al., 2017; Rynkiewicz et al., 2016), our study shows that these behaviors may emerge in females even as early as two years of age, although older and more developmentally advanced girls within our sample tended to show more JA behaviors. However, a main effect of biological sex on responding to BR was also found for ASD girls, such that girls overall were more likely to respond to examiner prompts. Our study only hypothesized that JA behaviors may play a role in the emergence of possible camouflage behaviors; therein, future research should examine girls' responding behaviors as a potential means of early social camouflaging.

Additionally, this study was strengthened by its use of a relatively large, developmentally matched sample of ASD girls (N=39). Due to the ASD female ascertainment bias and likelihood of a later diagnosis in females, it can be exceptionally hard to recruit ASD females for research all together, let alone very young ASD girls (Bargiela et al., 2016; Duvekot et al., 2017;

McCormick et al., 2020; Salomone et al., 2015). Moreover, as research has shown that girls are more likely to be diagnosed if they have higher reported behavioral problems (Duvekot et al., 2017) and are minimally or non-verbal (Salomone et al., 2015), it may be even more difficult to identify very young ASD girls who do have complex language and do not exhibit profound behavioral problems.

Limitations

This study had the following limitations. First, this study relied on frequency and percentage scores of children's social communication use. Therein, we were unable to examine social communication bids and responses qualitatively. Future research should seek to examine both frequency and quality of social communication behaviors. In particular, studies should examine the vividness with which ASD girls may use JA behaviors specifically because prior research has shown that girls display greater vivacity when using non-verbal gestures, compared to boys, when completing the ADOS-II (Rynkiewicz et al., 2016).

Research should examine social communication and camouflaging more naturalistically (i.e., parent-child interactions). While the ESCS is a well-validated and efficacious measure of social communication in children ages 14-30 months, it is a structured measure usually done in a laboratory setting and requiring the child to interact with an unfamiliar examiner and a variety of new objects. Children may exhibit different behaviors across settings or with a parent compared to an unfamiliar adult. Additionally, our study was not longitudinal. Therein, while our study provides an important measure of social communication behaviors in early childhood ASD, we were unable to track the development of social communication behaviors across settings or over time. Longitudinal and more naturalistic findings will be necessary to make further conclusions about the possible emergence of camouflage behaviors in very young ASD girls.

Conclusions

This research contributes to the larger literature suggesting that diagnostic tools for young ASD children may not be sensitive enough in capturing the female autism phenotype, particularly a greater ability to engage in social interaction. Future research should seek to more accurately capture a diagnosis of ASD in girls who may still appear particularly socially driven. Ultimately, advancing ways to measure the potential camouflaging behaviors in very young ASD girls will aid in more acute detection of this social disorder, allowing ASD girls to obtain necessary intervention services as early as possible.

Table 1. Sample Characteristics by Study

	Study 1		Study 2		Study 3		Study 4	
	Girls	Boys	Girls	Boys	Girls	Boys	Girls	Boys
N	5	5	16	16	6	6	12[a]	12
ADOS Module (1:2)	4:1	4:1	15:1	14:1	6:0	6:0	8:4	8:4
ADOS Total Score at Entry	14.20	14.00	15.93	15.80	13.83	14.67	14.50	17.08
Chronological Age (months)	49.60	37.00	31.81	31.56	44.50	42.50	46.75	50.92
MSEL Age Equivalent	34.40	28.40	20.92	20.12	25.83	22.08	30.54	35.02
MSEL Developmental Quotient	69.51	76.46	64.81	64.39	58.11	51.26	67.80	68.42
Race/Ethnicity								
African American	2	1	0	0	0	0	2	1
Asian	1	0	2	1	3	4	1	1
Hispanic	1	3	1	1	0	0	2	2
White	0	0	10	11	1	0	3	5
Other/Multi	1	1	3	3	2	2	2	2
Missing	0	0	0	1	6	6	2	1

Note: [a] MSEL scores were missing for one case in Study 4, so that case and its matched pair were removed from study analyses.

Figure 1. Association between developmental age (MSEL Age Equivalent) and child IJA coordinated joint looks moderated by biological sex.

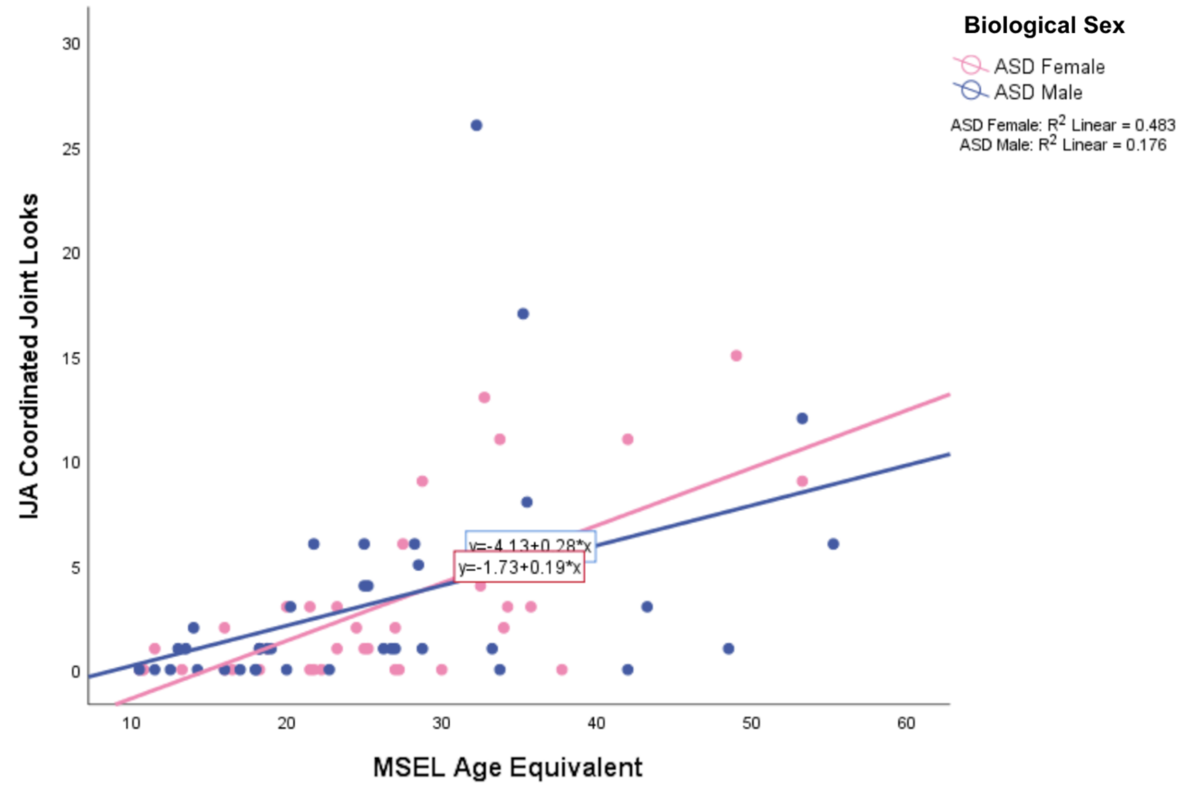

Figure 1. MSEL age equivalents significantly moderated the relationship between biological sex and IJA coordinated joint looks [F = 7.79, p = .001, $\eta^2 = .18$]. More cognitively advanced females use more coordinated joint looks than cognitively advanced males. Conversely, less cognitively advanced females used lower amounts of coordinated joint looks to initiate JA.

Figure 2. Association between developmental age (MSEL Age Equivalent) and child IJA points moderated by biological sex.

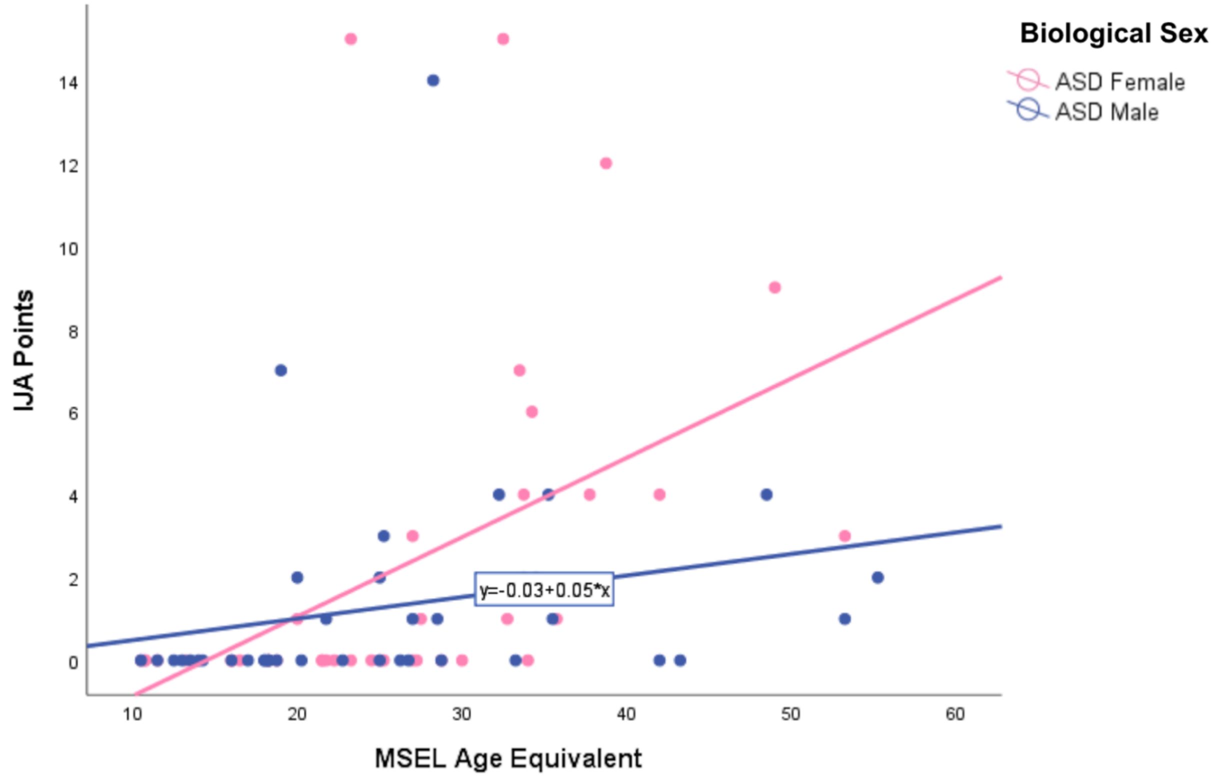

Figure 2. A significant interaction effect of MSEL age equivalents on the relationship between biological sex and IJA points was found [F = 3.85, p = .026, η^2 = .09]. Children's MSEL age equivalents moderated the effect of biological sex on IJA points such that females who were more cognitively advanced utilized more IJA points than cognitively advanced males. Conversely, less cognitively advanced females used fewer IJA points compared to their less cognitively advanced male counterparts.

Figure 3. Association between chronological age and child RJA book point percentages moderated by biological sex.

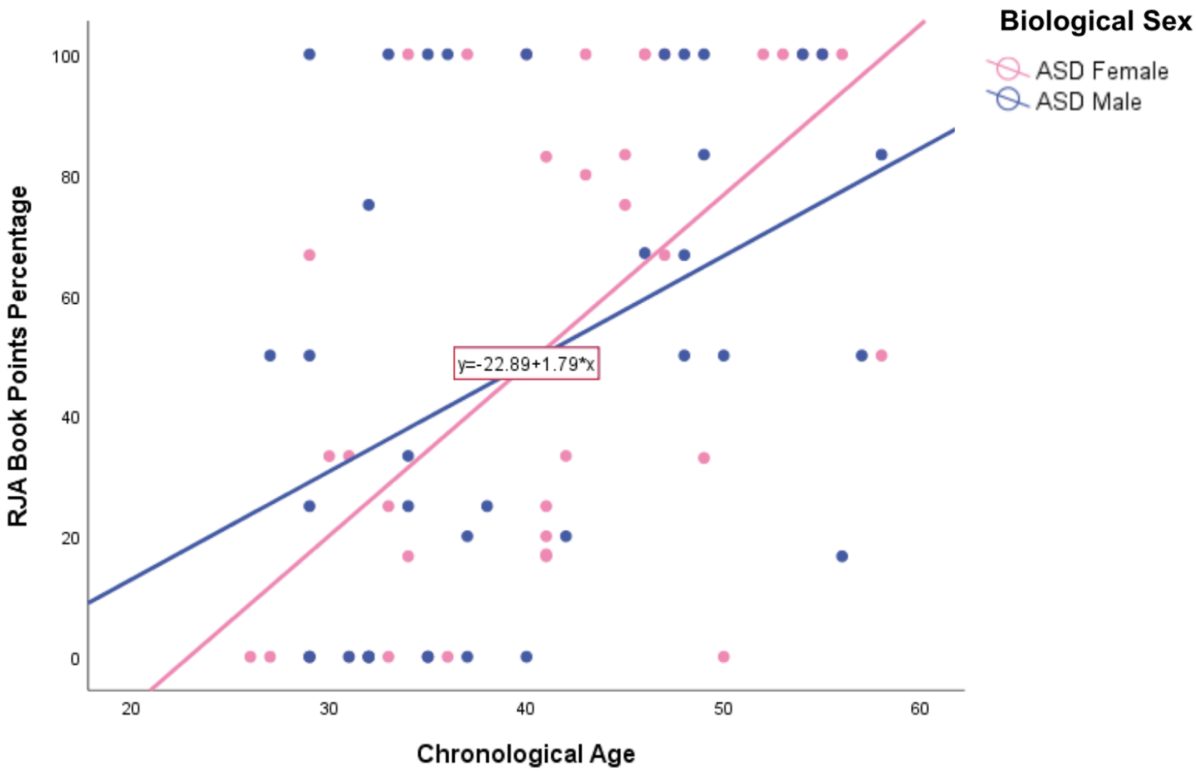

Figure 3. Chronological age significantly moderated biological sex and its effect on RJA book point percentages [$F = 4.26$, $p = .018$, $\eta 2 = .106$]. Therefore, more cognitively advanced females were more likely to respond to the examiner's book points.

Figure 4. Association between developmental age (MSEL Age Equivalent) and child RJA book point percentages moderated by biological sex.

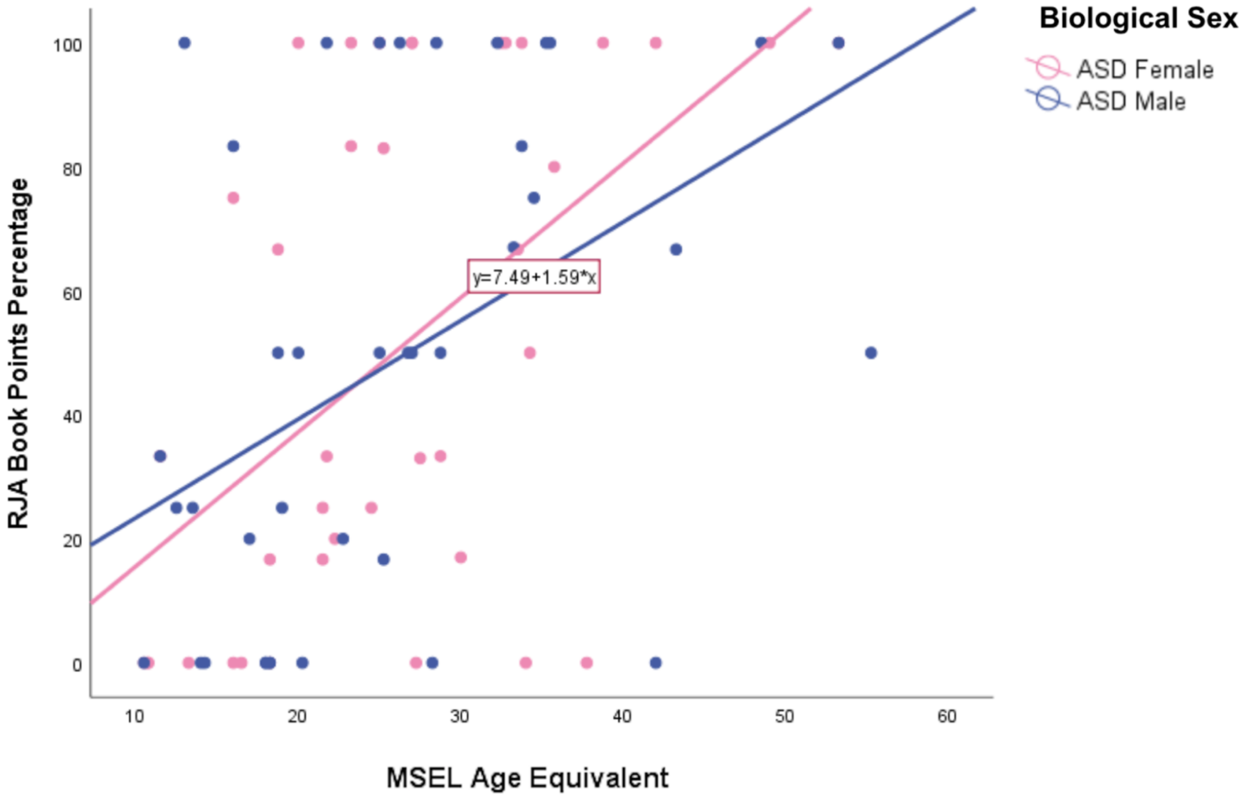

Figure 4. MSEL age equivalents significantly moderated the effect of biological sex on RJA book point percentages [$F = 3.10$ $p = .051$, $\eta 2 = .08$]. Therefore, older females were more likely to respond to the examiner's book points.

Figure 5. Association between developmental age (MSEL Age Equivalent) and child RJA line of regard percentages moderated by biological sex.

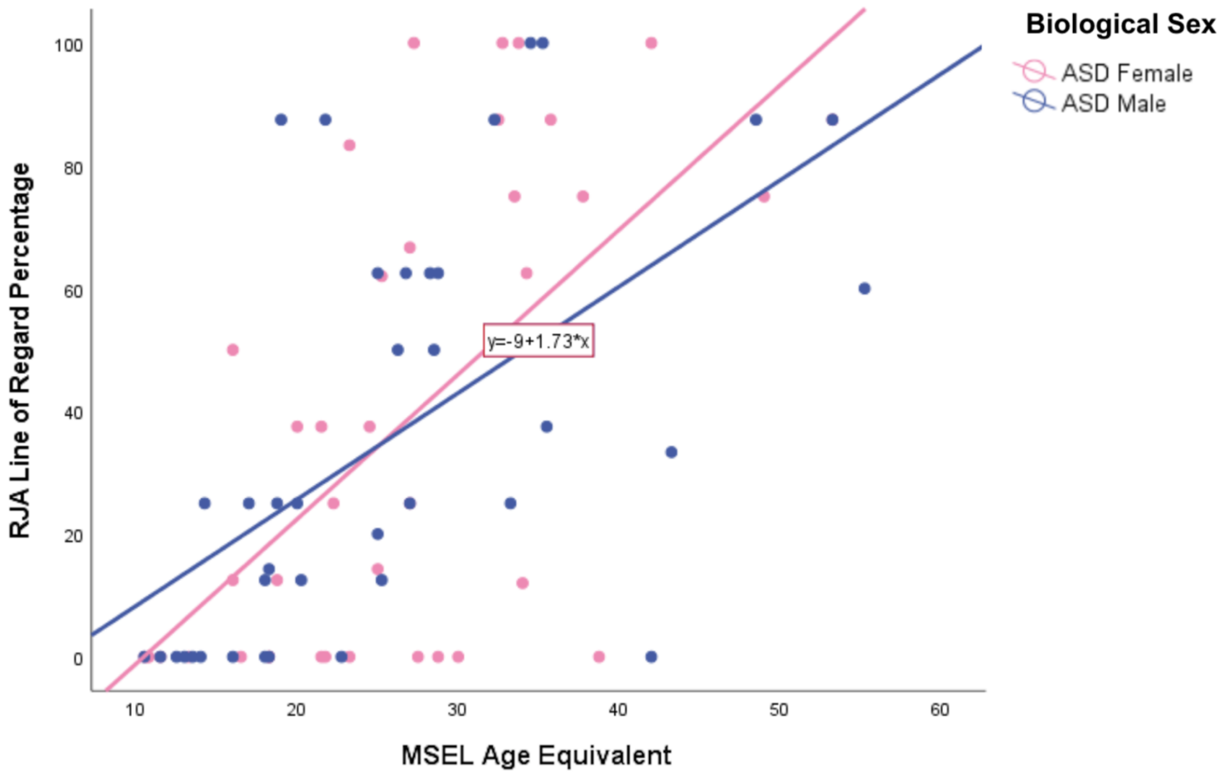

Figure 5. MSEL age equivalents significantly moderated the relationship between biological sex and RJA Line of Regard [F = 15.12, p = .000, $\eta^2 = .30$] such that females responded more to an examiner's line of regard points when they were more developmentally advanced.

Figure 6. Association between chronological age and child IBR points moderated by biological sex.

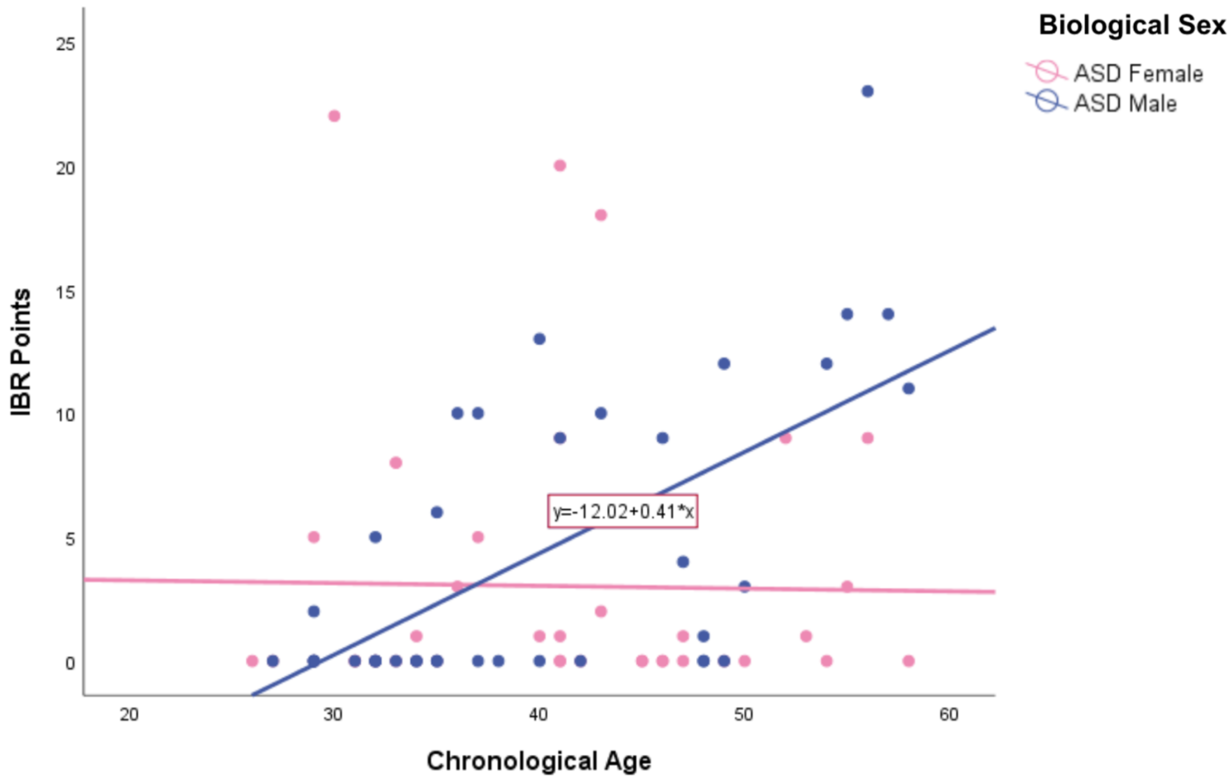

Figure 6. Chronological ages significantly moderated the relationship between biological sex and IBR pointing bids [F = 5.53, p = .006, $\eta^2 = .13$]. In other words, older males were more likely to use pointing bids to request compared to older females.

Figure 7. Association between chronological age and child IBR reaches moderated by biological sex.

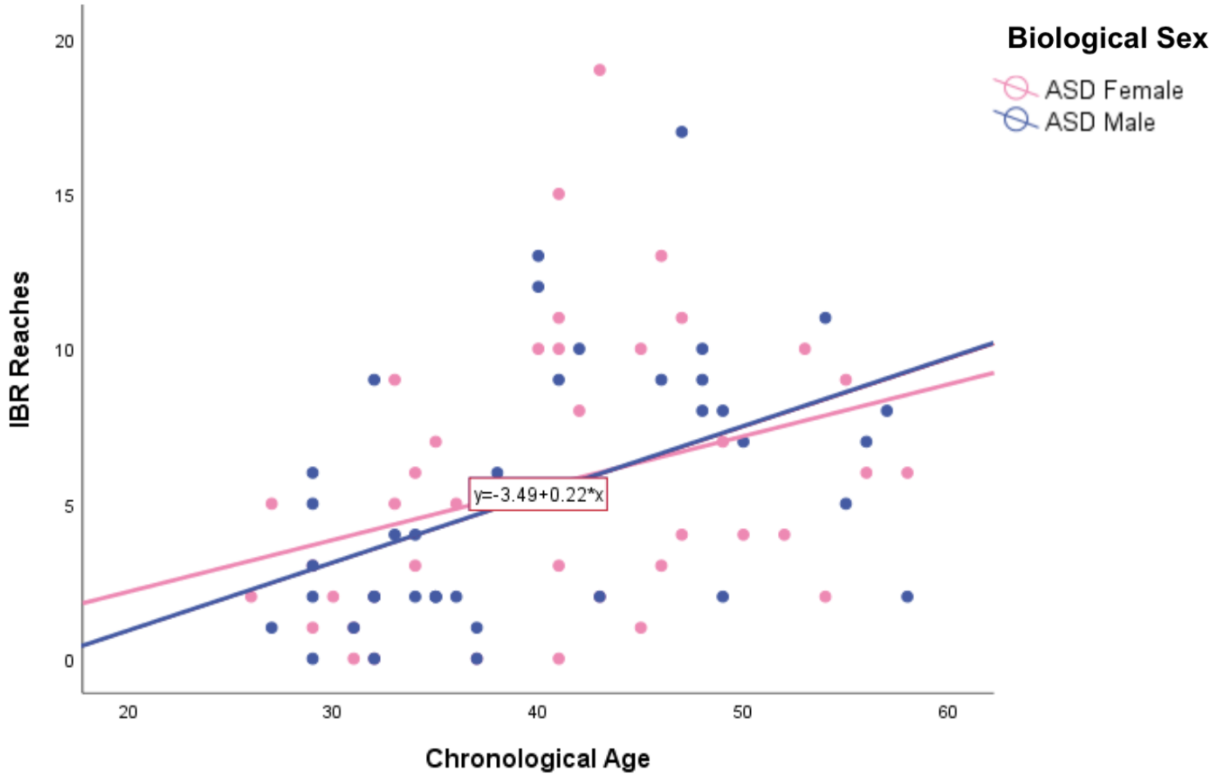

Figure 7. A significant interaction was found such that chronological ages moderated the effect of biological sex on IBR reaches [F = 5.20 p = .008, ŋ2 = .12]. In other words, older males used more reaching behaviors to request compared to older females.

Figure 8. Association between chronological age and child RBR without gesture moderated by biological sex.

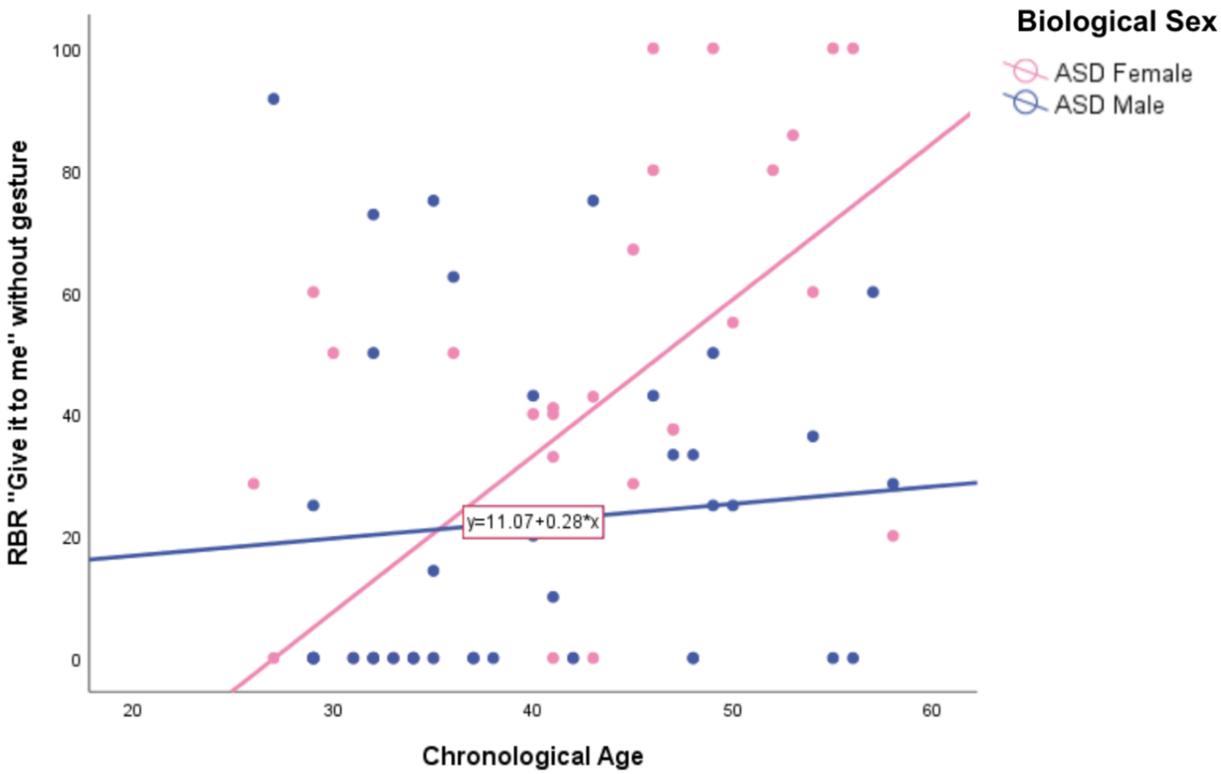

Figure 8. Chronological ages significantly moderated the effect of biological sex on RBR without Gestures [F = 3.10, p = .051. ŋ2 = .08]. Older females were more likely to respond to RBR requests that did not have gestures compared to boys.

Figure 9. Association between developmental age (MSEL Age Equivalent) and child RBR without gesture moderated by biological sex.

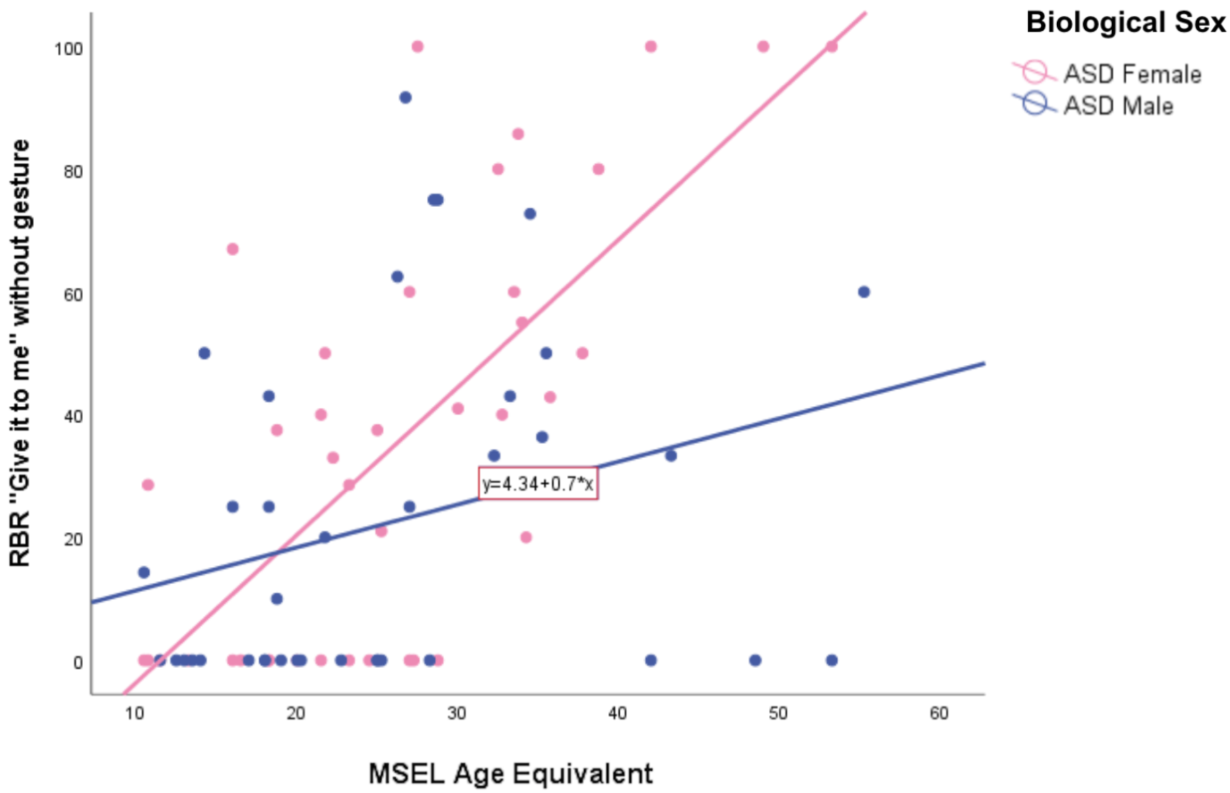

Figure 9. MSEL age equivalents significantly moderated the effect of RBR without Gestures [F = 7.72, p = .001. ŋ2 = .18]. Thus, more cognitively advanced females were more likely to respond to RBR requests that did not have gestures compared to boys.

Figure 10. Association between chronological age and child RBR with gesture moderated by biological sex.

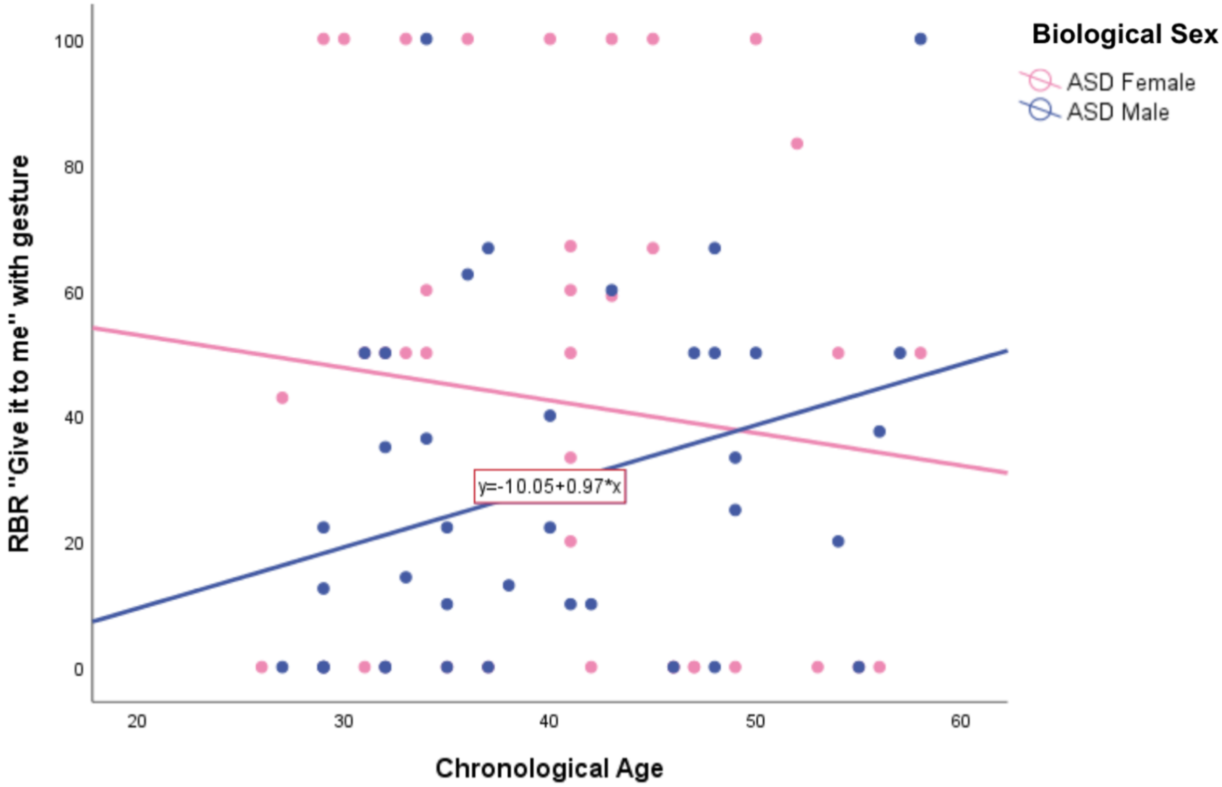

Figure 10. An interaction approached significance such that chronological ages moderated the effect of biological sex on RBR with Gestures [F = 2.82, p = .066, ŋ2 = .07].

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